Voyager

BULLETIN

MISSION STATUS REPORT NO. 96 **OCTOBER 4, 1989**

Neptune's three most prominent features—the Great Dark Spot, the bright Scooter, and Dark Spot 2 with its bright core—move at different velocities and only occasionally appear close to each other as seen here. (P-34648)

"You have earned the highest marks for making the solar system intelligible to the world at large in a most meaningful way. The integrity of the program and its participants was manifest to the world; we are all extremely proud of it.

I salute the entire Voyager team from first to last for such a significant and permanent positive addition to human knowledge and human horizon. This was the kind of excitement that counts. Well done!"

Richard H. Truly
Administrator, NASA

The pinwheel (spiral) structure of both the dark boundary and the white cirrus suggest that the Great Dark Spot is a storm system rotating counterclockwise. (P-34672)

Neptunian Meteorology

With the completion of Voyager 2's grand tour of the outer planets, Neptune "the mystic"* has at last yielded some of its long-kept secrets.

Prior to Voyager 2's visit we didn't know even basic information about the fourth giant planet, such as the length of its day or whether it had a magnetic field. While analysis of Voyager's data continues, a summary of the quick-look results will be given here.

Although Neptune receives only 1/900th as much energy from the Sun as the Earth does, it reemits about three times this amount—an indication that heat is being generated in Neptune's interior and radiated to space. Scientists have long thought that the winds in a planet's cloud tops are driven by the Sun's heat, but now they must consider more strongly the contributions of the planet's own interior heat source.

Voyager's infrared observations of Neptune showed that temperatures are warmer near the equator and south pole, and cooler in mid-latitudes—surprisingly similar to the case at Uranus. Since the south pole is tilted slightly toward the Sun at this point in Neptune's orbit, it is not surprising that it is warm. But the warmth at the equator is surprising because less sunlight falls there due to the planet's tilt. Voyager's ultraviolet investigation measured temperatures at high altitudes in Neptune's stratosphere at about 400 kelvins (250°F), while the infrared investigation measured the temperature at the 100 millibar pressure level to be about 55 kelvins (–360°F).

While analysis continues, the results of the radio science investigation seem consistent with an atmospheric chemical composition of about 85 percent molecular hydrogen, 13 percent helium, and 2 percent methane. The infrared investigation's results indicate that some amount of acetylene exists as well.

Neptune is the densest of the four giant planets, about 64 percent heavier than if it were composed entirely of water.

Hints of cloud systems had been observed from Earth-based telescopes for the past several years, but only when Voyager arrived could we discover that Neptune is banded and has a number of dark spots, bright spots, and cirrus clouds. As on other planets, wind shears occur at the boundaries between eastward and westward bands.

The Great Dark Spot, at about 22 degrees south latitude, is probably at lower altitude than its accompanying bright clouds. The size of the Great Dark Spot in its east–west extent is comparable to the diameter of the Earth—over 12,500 kilometers (nearly 8,000 miles). Time-lapsed movies constructed from single frames show that the Great Dark Spot is not totally oval, has spiral arms, and appears to have a counterclockwise circulation pattern. Imaging scientist Dr. Andy Ingersoll of Cal-

*From Gustav Holst's symphony, *The Planets*.

Banding surrounding Dark Spot 2 indicates unseen strong winds, while structures within the bright spot suggest both active upwelling of clouds and rotation about the center. (P-34749)

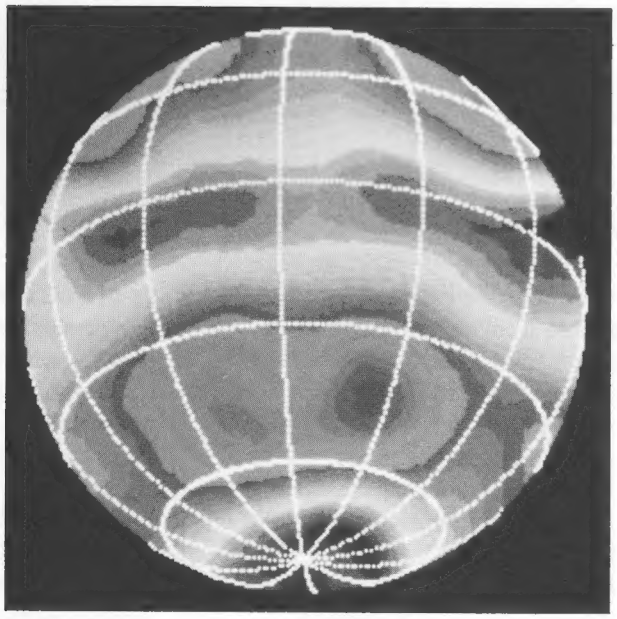
A cylindrical projection view of Neptune ranges from 80 degrees south of the equator to 30 degrees north and shows the large storms and wave patterns stretching around the planet. (P-34630)

tech drew chuckles with the remark that the Great Dark Spot looks like "a great glob of pizza dough going around." The Great Dark Spot circles Neptune in a little less than 18 hours, implying that it is in an atmospheric zone with westward (retrograde) winds of more than 300 meters per second (700 miles per hour!). Bright, wispy, "cirrus-type" clouds overlie the Great Dark Spot at its southern and northeastern boundaries.

According to atmospheric scientist Dr. Jim Pollack of NASA's Ames Research Center, some of the bright spots on Neptune may be convective clouds rising above the base of the methane clouds. He suggests a cycle of methane on Neptune wherein ultraviolet sunlight first converts methane to hydrocarbons in the stratosphere. The major hydrocarbons, such as ethane and acetylene, then drift down to the colder lower stratosphere, where they evaporate and condense into hydrocarbon ices. These ice particles fall into the warm troposphere, evaporate, and are converted back to methane. The methane is returned to the stratosphere by buoyant convective methane clouds, which rise to the base of the stratosphere or higher. The bright central core of the southern dark spot is probably such a rising convective cloud, and the bright cloud at about 42 degrees south latitude may be interpreted as a cloud plume rising between the methane and hydrogen sulfide cloud decks.

As Voyager 2 approached the planet, imaging scientists were able to track the features in the clouds to determine the wind speeds. They were surprised to find that some features, such as the Great Dark Spot, had a rotation period of 18 hours, in close agreement with ground-based observa-

High, bright cloud streaks cast shadows on cloud decks as much as 50 kilometers (30 miles) below them. The cloud streaks are 50 to 200 kilometers (30 to 125 miles) in width, while the shadows are 30 to 50 kilometers (20 to 30 miles) in width. (P-34709)



An infrared map of brightness temperatures shows that Neptune is warmer near the equator and south pole and cooler in the mid-latitudes. (JPL 12391AC)

tions, but that other features moved much faster. The bright cloud at about 42 degrees south latitude was nicknamed "Scooter" because of its 16-hour rotation period. However, motions in the atmosphere are indicative only of wind speeds. The rotation of the bulk of the planet can best be measured by studying the periodicity of the planet's radio signals, generated by deep-seated convection currents in the planet's interior, and carried to space along the planet's magnetic field lines. The Planetary Radio Astronomy Team, led by Dr. Jim Warwick of Radiophysics, Inc., determined from Neptune's radio signals that a Neptunian day is 16 hours 3 minutes.

Dr. Brad Smith, leader of Voyager's Imaging Science Team, suggests that the clouds near the Great Dark Spot are not moving rapidly themselves, but that the air around them is, analogous to lenticular clouds that form over mountains here on Earth. As winds go through the region, they are deflected upward where the volatiles condense out and form clouds.

Voyager also saw cloud shadows in Neptune's south polar region, the first time a Voyager spacecraft has been able to see such features on any planet. The shadows are cast by methane cirrus-like clouds that are estimated to be 50 to 75 kilometers (30 to 45 miles) above the haze or stratus clouds.

NASA
National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

JPL 410-15-96 10/89

Editor
Anita Sohus (818) 393-0683

Technical Review
Voyager Project Staff

Public Information Office
(818) 354-5011

Public Education Office
(818) 354-8594